A comparison of several indices for assessing body condition of Mongolian gazelle

LI Jun-sheng (李俊生)*, ZHOU Hong-li (周宏力), YUAN Li (袁力), ZHANG Dong-mei (张冬梅)
(Northeastern Forestry University. Harbin 150040, P. R. China)

Abstract: Riney kidney fat index (RKFI), whole kidney fat index (WKFI), femur marrow fat index (FMFI), and tibia marrow fat index (TMFI) of 51 Mongolian gazelles (*Procapra gutturosa*), collected in Hulunbeier grassland, Inner Mongolian, China, were measured during spring, autumn and winter in 1997-98. These different indexes were compared for using them in assessing the body condition. There was a linear relationship ($y=0.9444x-20.139$; $r=0.9454$; $p<0.01$) between RKFI and KMFI. A linear relationship ($y=0.9348x+1.1843$; $r=0.9875$; $P<0.01$) between TMFI and FMFI also occurred for gazelles. There was a curvilinear relationship ($y=31.44Ln(x) -44.403$; $r=0.8643$; $P<0.01$) between FMFI and RKFI. FMFI remained high, while RKFI decreased to a certain extent. After most of the kidney fat was used, the femur marrow fat abruptly decreased. The results showed that the kidney fat index is more adequate for evaluating the population nutrition in good condition, but marrow fat index was more useful for assessing in poorer nutritional condition.

Key words: *Procapra gutturosa*, fat indexes, nutritional condition assessment
CLC number: Q954 **Document code:** A **Article ID:** 1007-662X(2000)04-0245-04

Introduction

Riney (1982) stated that body physical condition of animals respond quickly to environmental changes and provide a good index to a population's response to these changes after minimal time-lag, thus facilitating a more precise understanding of cause-effect interrelations between animals and their environment. In this regard, a measurement of fat reserves provides the best index to the physical condition of a wide range of mammal (Riney 1955). For measuring carcass fat, various methods have been devised and proposed. These methods include kidney fat index, bone marrow fat index, rump fat index, dissectible fat index, chemical composition of indicator muscles, densiometric measurements, tissue sawdust analysis, body mass, organ or gland mass, and relationships between body mass and various body dimensions. Of these methods, the kidney fat index and marrow-fat content were considered to be the most useful for assessing fat reserves of animals (Riney, 1982).

Mongolian gazelle (*Procapra gutturosa*) are an important wild ruminant in eastern Inner Mongolian Grassland. It used to be the most numerous and an important component of the grassland ecosystem. However, the population is now decreasing and facing extinction in China. Therefore, it is very important to construct the conservation program. The nutritional ecology study on Mongolian gazelles should be an important part of the program. As for the Mongolian gazelle, the above methods of nutritional condition evaluation have not yet been applied. Consequently, in this study we evaluated kidney fat, bone marrow fat, and body mass as condition indices in Mongolian gazelle by comparing them with estimated total body fat.

Study areas

Study areas is in Xiqi where is situated in the southwestern part of Hulunbeier Grassland (47°39'~49°50' N, 115°00'~114°8'E) and is a main distribution region of Mongolian gazelles in China. The climate type of the region belongs to continental arid in temperature zone. Annual temperature averages -1°C. Temperature extremes are –35.4 °C and 34.6 °C, and the average total annual precipitation around study areas is less than 250 mm, about 60% of yearly precipitation occurs from July to September.

Vegetation type belongs to the Europe--Asia Plateau Vegetation Region. Main plateau plant types include that *Stipa grandis* steppe, *Aneurolepididum chinenese* steppe. Dominant species mainly include *Stipa grandis, S. krylovii, Aneurolepididum chinenese, Agropyron cristatum, Koeleria cristatta, Clestogenes squarrosa, Allium prostratum, Carex duriuscula, Caragana incrophylla* etc.

Material and method

A total of 51 Mongolian gazelles were killed near the border of China—Mongolia in spring (in April),

---

Biography: *LI Jun-sheng (1968-), Male, Lecturer in Northeast Forestry University. Harbin 150040, P. R. China.
Received date: 2000-01-05
Responsible editor: Chai Ruihai

autumn (in November) and winter (in February) from 1997 to 1998. After being shot the gazelles were sexed, weighed, and dissected immediately, then the samples were collected.

The kidney was removed along with surrounding fat and weighed. Then, the surrounding fat anterior and posterior to the kidney was cut as was done by Riney (1955), and the kidney and remaining fat were weighed. Next, the fat was peeled away from the surface and the kidney was weighed without fat. Thus, Riney's kidney fat index (RKFI) was obtained by expressing the weight of the remaining fat around the kidney as a percentage of the kidney weight.

The whole kidney fat index (WKFI) was also obtained by expressing the weight of the whole fat around the kidney as a percentage of the kidney weight. Since both the kidney and the surrounding fat weights were different on both sides, the average of both side values was calculated and used for both RKFI and WKFI.

The left femur and tibia were removed during necropsy and sealed in a plastic bag and frozen. Both bones were later thawed when the marrow's fat content was measured. For chemical and dry weight determinations of the marrow fat content, a sample of 2-3 g was taken from the central part of the marrow. Samples were dried in an oven at about 80 °C until constant weight achieved. This dry weight was expressed as a percentage of the fresh weight. The dried samples were then transferred to an apparatus and the fat was extracted with alcohol-benzene (1:1) for 18 h, after which the extracted fat was dried and weighed. This dry fat weight was expressed as a percentage of the fresh weight of sample.

Ages were estimated by observing tooth wear and measuring the dental cement layer of the first molar of the left mandible, and using the horn year—ring method devised by Jiang *et.al* (1992)

Results

Kidney fat indexes

Fig.1 shows a linear regression equation relating RKFI (%) and WKFI (%) to body mass (kg). The regression equations of kidney fat index and body mass were as follows: $y=1.6477x+64.249$ and $y=5.5634x-11.258$, respectively. Their correlation coefficient were low, r(RKFI)=0.3635 and r (WKFI)= 0.6978, and the correlation coefficient between WKFI and body was larger than that between RKFI and body.

Comparing with RKFI, the whole kidney fat index (WKFI), expressing as the weight of the whole fat around the kidney as a percentage of the kidney weight, showed larger values in the same group of samples. Fig. 2 shows the relationship between RKFI and WKFI in the gazelles. A linear regression could be expected in this relation, the correlation coefficient was as high as r=0.9454. The prediction of RKFI (y) from WKFI (x) was given by $y=0.9444x-20.139$ ($P<0.01$). In this regression, WKFI values tend to be overestimated to some extent from RKFI values in the lower fat level.

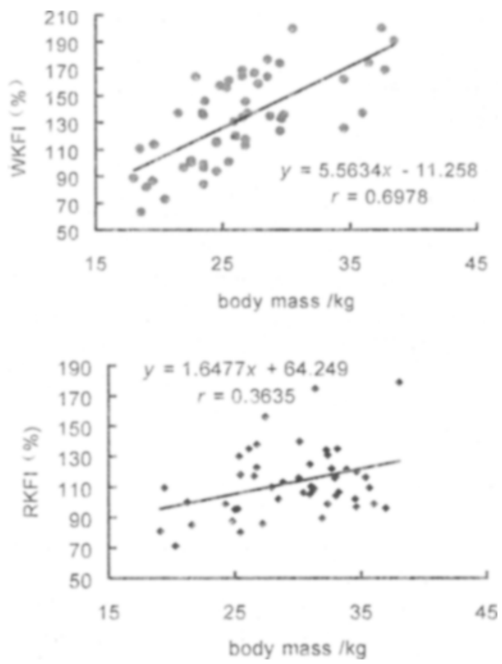

Fig. 1 Regression equations relating RKFI and WKFI to body mass for Mongolian gazelles

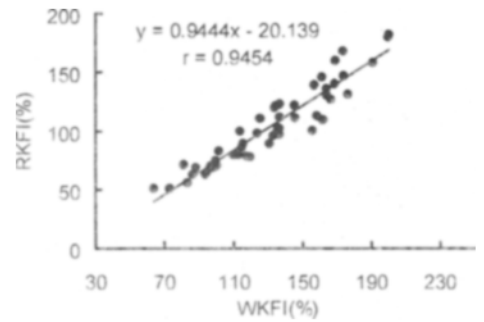

Fig. 2 Relationship between RKFI and WKFI in the Mongolian gazelles

Table 1 also shows left and right kidney weights were different in samples, and left kidneys were heavier than right kidneys ($P<0.05$) for whole gazelles except fawn females in spring. The differences in adult were consistent across seasons (Table 1). No differences were detected in mean or left kidney weights across seasons in adult females, but mean kidney weights of fawns did differ, weights in winter and spring were greater than in autumn.

Table 1. Body weights and kidney weights and kidney fat indices (%) in different seasons for Mongolian gazelles

Sex/ age	samp. Date	Body Weight /kg	Kidney weight /g Left	Kidney weight /g Right	Value of WKFI (%) Left	Value of WKFI (%) Right	Value of RKFI (%) Left	Value of RKFI (%) Right
	Spring	26.61 (5.01)*	50.33 (6.02)	49.50 (6.37)	19.81 (5.07)	15.30 (6.40)	12.60 5.65)	9.62 (5.76)
Male/fawn	Autumn	26.03 (4.11)	32.01 (3.14)	32.32 (4.12)	71.43(21.52)	75.01(20.74)	50.67(26.48)	52.87(22.61)
	Winter	25.08 (3.90)	29.97 (4.22)	28.89 (4.01)	79.83 (21.11)	77.92(23.09)	51.57(16.91)	50.79(19.06)
	Spring	33.5 (2.23)	58.28(12.29)	56.43(13.43)	23.31 (6.86)	18.01(6.48)	16.54 (6.18)	11.73(5.33)
Male/adult	Autumn	31.91 (2.66)	47.55 11.30)	46.97(10.56)	57.89(23.06)	58.36(20.97)	37.01(11.03)	36.93(12.67)
	Winter	33.8 (1.66)	44.36 (6.45)	43.01 (7.13)	59.66(25.96)	61.79(23.30)	39.68(13.20)	38.16(11.23)
	Spring	21.09 (2.30)	31.77 (7.12)	33.09 (6.13)	17.66 (1.33)	13.18(3.20)	10.09 (0.26)	9.91(1.01)
Female/fawn	Autumn	24.11 (3.01)	25.09 (6.88)	24.21 (6.99)	165.75(36.11)	159.87(35.87)	124.49(33.39)	127.40(30.88)
	Winter	22.53 (3.12)	29.77 (3.09)	26.63 (1.28)	143.05(38.10)	101.44(34.87)	92.99(25.36)	66.78(26.36)
	Spring	27.70 (3.25)	43.01 (7.01)	42.00 (5.31)	20.87 (6.58)	21.76(2.49)	17.40 (5.48)	14.88(4.40)
Female/adult	Autumn	26.11 (3.33)	43.13 (8.07)	40.99 (6.97)	89.69 (6.78)	90.15(5.97)	62.13 (7.11)	64.88(6.11)
	Winter	29.62 (2.82)	38.98 (5.60)	38.10 (3.60)	75.84 (23.90)	80.42(22.05)	50.23(17.75)	52.96(14.41)

Note: * stander for value of SD.

Bone marrow fat indexes

Bone marrow is composed of fat, water, and non-fat residue. Non-fat residue is included constantly in a small amount of several percent. Small amounts of non-fat residue were also found in the Mongolian gazelles 4.11±2.05(SD)% in the femur bone marrow and 3.87±1.96(SD)% in the tibia bone marrow. However, no clear relationships between non-fat residue and other two elements were found.

Marrow levels of the animals collected during February to April (winter and spring) were lower ($P<0.05$) than of those collected during September to November (autumn) for lambs, yearlings, 2-year-olds, and adult male. No different ($P<0.05$) was found in marrow levels of adult females, especially in pregnant females. The marrow levels of pregnant females were larger than that of non-pregnant females, and it was larger in adult females than in adult males. However, no different was found between the marrow levels of fawn males and females.

In 51 Mongolian gazelles, the regression equation of both marrowfat of femur (x) and tibia (y), were as follows: $y=0.9348x+1.1843$ ($r=0.9875$, $P<0.05$)(Fig. 3.). As the Fig.3, a good correlation was obtained, and occasionally, the tibia marrow fat values were found to be larger to some extent than femur marrow fat values. However, discrepancy of both values was not prominent and was considered negligible for practical purposes.

Relationship between kidney fat index and bone marrow fat index

Fig.4 shows FMFI plotted against RKFI for the Mongolian gazelles. FMFI remained high, while RKFI decreased to a certain extent. After most of the kidney fat was used, the femur marrow fat abruptly decreased. The decrease of FMFI value began at a RKFI value of about 30% in the Mongolian gazelles. The relationship between the FMFI and the RKFI was different in different sex/age groups. In 20% of RKFI, the adult female showed a significantly larger FMFI value than the other sex/age groups and the yearling showed significantly larger FMFI value than the fawn ($t=4.66$, $P<0.05$). In both divisions of 20%<RKFI<30% and RKFI <20%, no significant difference was found in FMFI values between the adult and yearling. However, the value of the fawn was smaller than that of the yearling.

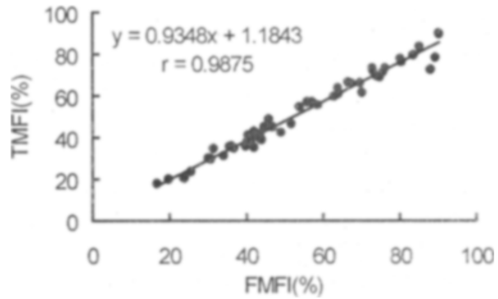

Fig. 3 Relationship between TMFI and FMFI in Mongolian gazelles

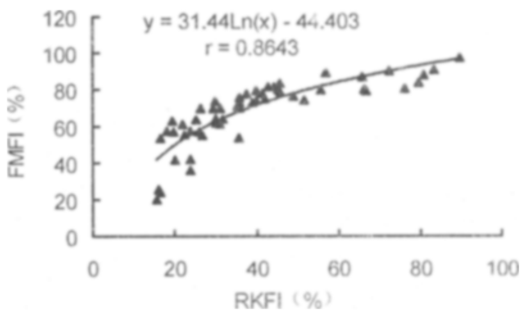

Fig. 4 FMFI plotted against RKFI for Mongolian gazelles

Discussion

The kidney fat index is a good indicator of a wide range of body physical conditions from rich to poor (Riney 1955). So, Riney suggested that kidney fat

indexes could be used for comparison of seasonal and annual fat levels both within and between populations. Because the linear and log transformed models fit kidney fat index to total body fat for most of ruminant (Torbit *et al.* 1988). Robbins (1983) pointed out that the curvilinear relationship between kidney fat index and total body fat is the biologically correct expression. However, the value of the index has subsequently been questioned, mainly because seasonal changes in kidney mass distort interseasonal comparisons (Van Vuren and Coblentz 1985). And Van Vuren and Coblentz (1985) also found it more meaningful to relate perirenal fat to total body mass. In this study, the kidney weight of Mongolian gazelles was significantly seasonal changes in different sex/age groups except the pregnant females. This may lead to an underestimation of kidney fat index for fawns and calves. Age--related difference also has been reported in white-tailed deer (*Odocoileus virginianus*) (Johns *et al.* 1980) and feral sheep (*Ovis aries*) (Van Vuren and Coblentz 1985). Riney's kidney fat index and the whole kidney fat index of Mongolian gazelles both were correlated with body mass. However, the fig.1 illustrated that the whole kidney fat index was larger in correlation coefficient than the Riney's kidney fat index. This indicates that the whole kidney fat index was more significant for evaluating the Mongolian gazelles population nutritional condition than the Riney's kidney fat index.

In measurements of marrow fat, the femur marrow is usually analyzed. The tibia marrow is also useful because both values of tibia and femur fats were not largely different. Sinclair and Duncan (1972) also stated that the samples from other long bones did not differ by more than 10% fat content from the figure found in the femur, even in animals with very low marrow fat. In this study, occasionally, the tibia marrow fat values were found to be larger to some extent than femur marrow fat values. However, discrepancy of both values was not prominent and a good correlation was obtained from both the bone marrow fat indexes. So, the small difference was considered negligible for practical purposes.

This study supported Mech and Delgiudice's (1985) general conclusion that if bone marrow has lost any significant amount of fat, the individual probably is in poor nutritional condition. This is a consequence of marrowfat being depleted as the last fat depot, and the relatively small reserves observed in bone marrow. The RKFI values which indicates the starting point of femur marrow fat decrease was not evident but seemingly about 30% for Mongolian gazelles. For the poor condition under this value of Riney's kidney fat index, bone marrow fat index should be exclusively used to assess the nutritional conditions of animals. Ratcliffe (1980) suggested that femur fat in the 75%-80% range on a wet-weight basis during winter was indicative of healthy European roe deer (*Capreolus capreolus*). Peterson *et al.* (1982) assumed that marrow fat values below 80% on a wet-weight basis indicated net fat depletion of bone marrow depots of moose (*Alces alces*). However, Cederlund *et al.* (1989) reported that marrow fat values of about 40% on wet-weight in presumably healthy moose, indicating a certain mobilization of bone marrow fat in an early phase of depletion. This study obtained a bone marrow fat content between 30%-40% on wet-weight during the winter of 1997, indicating heavy nutritional stress. These indicated that there was a various nutritional stress indicator of bone marrow fat values in different species.

In conclusion, the kidney fat index and marrow fat index were also useful indicators to assess the nutritional conditions of Mongolian gazelles with a wide range of conditions from poor to rich, as has been found in other ruminants by various investigators.

References

Cederlund, G.N., Bergstrom, R.L. and Danell, K. 1989. Seasonal variation in mandible marrow fat in moose [J]. J. Wildl. Magane., **53**: 587-592.

Jiang Zhaowen, Xu Li and Zheng Hong. 1991. The comparative analyses on age identification indexes of Mongolian gazelle [J]. Chinese Wildlife, **3**: 25-28

Johns, P.E., Smith, M.H. and Chesser, R. K. 1980. Effect of sex, age, habitat, and body weight on kidney weight in white-tailed deer [J]. Growth, **44**: 46-53.

Mech, L.D. and Delgiudice, G.D. 1985. Limitations of the marrow-fat technique as an indicator of body condition [J]. Wildl. Soc. Bull., **13**: 204~206.

Ratcliffe, P.R. 1980. Bone marrow fat as an indicator of condition in roe deer [J]. Acta Theriol., **25**: 333-340.

Riney, T. 1955. Evaluating condition of free-ranging red deer (*Cervus elaphus*), with special reference to New Zealand [J]. New Zealand J. Sci. & Tech. Sect. B, **36**:429~463.

Riney, T. 1982. Study and Management of Large Mammals [M]. New Zealand Sci. Press. Wiley

Robbins, C.T. 1983. Wildlife feeding and nutrition [M]. Acad. Press, New York, N. Y. 343pp.

Sinclair, A.R.E. and Duncan, O. 1972. Indexes of condition in tropical ruminants [J]. J. E. Afr. Wildl. **10**:143-149

Torbit, S.C., Carpenter, L.H., Bartmann, R.M., Alldredge, A.W., White, G.C. 1988. Calibration of carcass fat indices in wintering mule deer [J]. J. Wildl. Manage., **52**: 582~588.

Van Vuren, D. and B.E. Coblentz. 1985. Kidney weight variation and the kidney fat index: an evaluation [J]. J. Wildl. Manage., **49**: 177~17.